

Upgrading and Nitrification of Large Scale Plants Using Bio-Cord Reactors

Location: Geiselbullach, Germany

Source: T.H. Lessel on Upgrading and Nitrification By Submerged Bio-Film Reactors.

Introduction

The upgrading and nitrification was required for a conventional sewage treatment plant designed for 250 000 Inhabitants equivalent in Geiselbullach, Germany. Submerged rope type Bio-Cord Reactors were used in the aeration tank to increase the MLSS Concentration. The plant characteristics and operational data before upgrading are shown in Table 1:

TABLE 1

Waste Water Quantity	35 000 m ³ / d
Specific Space Loading	0.8 - 1.0 kg BOD / m ³ . d
MLSS	1.4-1.8 kg / m ³
Specific Sludge Loading	0.5 - 0.8 kg BOD / kg . d
Aeration Tank Volume	7800 m ³
Return Sludge Ratio	0.5 - 1.0 l
Sludge Volume Index	180 - ml / g

The Bio-Cord material consists of a flexible rope of polypropylene material with a number of woven rings. The cord was vertically fixed in cage with a cage volume of 25% of the tank volume. The test time with nitrification lasted six weeks. It was stated that the Bio-Cord are moving and swinging in the waster water by the turbulence, created by the aeration. Accumulation of dark sludge was not observed. The quantity of attached biomass was much lower than expected, however the nitrification process was stimulated in the same way as other reactors.

RESULTS

Sessile Biomass was found on the surface of the Bio-Cord Material just a few days after the plant operation began. The ropes changed the attached Biomass from "high amount" to "nearly nothing" within a few days and without a significant influence on the purification or the nitrification effect. The re-creation of the biomass then lasted perhaps two of three days this skinning effect did not influence the MLSS concentration either.

An important observation was that the sludge accumulation on the reactors were never anaerobic.

Results are summarized in Table 2

Table 2:

	BOD		COD		NH ₄ -N		BOD Sludge- Loading (kg/kg.d)	MLSS** In aeration Tank (g/l)	Isv (mg/l)
	IN (mg/l)	OUT (mg/l)	IN (mg/l)	OUT (mg/l)	IN* (mg/l)	OUT (mg/l)			
Without Reactors	170	11	310	53	36	32	0.56	1.6	198
With Reactors, Without P-removal, Unstable operation conditions	125	13	280	47	35	32	0.40	3.3	144
With Reactors, Without P-removal, Stable operation conditions	104	6	359	47	40	7	0.09	5.5	56
With Reactors, With P-removal, Stable operation conditions	148	4	402	38	39	1	0.13	6.0	42

* INFLUENT TO BIOLOGICAL TREATMENT, AFTER MECHANICAL TREATMENT.

** WITHOUT ATTACHED BIOMASS.

Summarized Results

- Anaerobic sludge accumulation on the Bio-Cord reactors did not occur.
- **MLSS concentration in the aeration tanks increased from 1.6 to 3.3 g/l (without P-Removal, unstable operation conditions) and to 6.0 g/l (with P-Removal, stable operation conditions).**
- **The sludge volume index reduced from 198 ml/g to 42 ml/g.**
- The nitrification could be achieved after a few days with the improved sludge concentration and could be maintained at oxygen concentrations of about 2.0 mg/l under stable operating conditions and at water temperatures of 8°C and higher. The system proved a remarkable buffer ability under disturbances, even at temperatures of 10°C.
- Waste water purification improved to concentrations of about 40% of the former BOD values and to about 70% of the former COD values.

- The quantity of sessile Biomass was in 3.5g and 11g range per meter of the cord. Corresponding to the suspended Biomass an increase of between 0.5g/l and 1.3 g/l was created.
- **The specific amount of excess sludge decreased from about 0.9 kg/kg BOD (influent to the biological treatment) after some weeks of stable operation to about 50% of this quantity.**

Discussion

Nitrifying micro-organisms generally grow if the sludge age is more than 8 days. Submerged Bio-Cord reactors can stimulate the biocenose towards nitrification.

Nitrifying bacteria were detected in the same relation to other organisms among the suspended Biomass. This effect is explained by an intensive exchange between the sessile Biomass and the floating Biomass.

As the higher developed organisms reduce the lower developed organisms the excess sludge quantity reduces significantly. This influences the cost for sludge treatment.

The effect of Bio-Cord reactors on the age and characteristics of sludge are significant.

The interaction of the sessile and suspended Biomass is more important for the nitrification process than a high amount of attached biomass.

The use of Bio-Cord reactors to create higher MLSS concentration is approximately 2.5 times more cost effective than building a conventional type aeration tank to achieve the same results.

A good biofilm must offer a high specific surface area, a good surface on which the bacteria can grow and can be held (Schulz 1993) and it must avoid the clogging by a surplus of biomass. The permeation of nutrients and oxygen into all parts of the biomass layers must be assured (Anonymous 1987, AVT 1987 & 1989, Scherb 1987).

Small Community Plant: Nitrogen Removal

Designed for 750 EP (Japan). Daily inflow 202.5 m³/d.

Daily BOD (Inflow): 40.5 kg/d

Samples Tested Over A Period of 7 Months.

Inflow



Storage Tank



Anaerobic Filter Tank 1	Chamber Volume 80 m ³	Filter Volume 60%
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Anaerobic Filter Tank 2	Chamber Volume 40 m ³	Filter Volume 58%
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Anaerobic Filter Tank 3	Chamber Volume 40 m ³	Filter Volume 50%
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Contact Aeration Tank 1	Chamber Volume 87 m ³	Filter Volume 60%
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Contact Aeration Tank 2	Chamber Volume 41 m ³	Filter Volume 60%
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Contact Aeration Tank 3	Chamber Volume 41 m ³	Filter Volume 60%
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Sedimentation Tank ⇒ Disinfection Tank ⇒ Out Flow

Return: Contact aeration tank 3 ⇒ Anaerobic filter tank 1

Small Community Plant (cont'd):

Test	Aeration (m ³ /hrs.)	Return Vol. (Daily)		St 1	St 2	St 3	St 4	St 5	St 6	St 7	St 8	% Removal
1	1.1~ 1.2	1.73Q	SS mg/l	113	35	14	8	4	3.5	2	2	98.2
			BOD	183	68	41	24	19	17	29	16	91.2
			C-BOD	133	57	26	19	15	12	9	8	93.9
			S-BOD	101	31	24	18	15	15	13	12	88.1
			COD	39	22	20	18	16	15	12	11	71.7
			NH4-N	18	13	13.5	14	12.5	9.5	7.6	7.4	
			NO2-N	0.18	0.26	0.21	0.15	0.2	0.31	0.35	0.35	
			NO3-N	0.6	0.98	0.15	0.1	0.12	0.12	0.1	0.1	
			ORG-N	0.11	0.14	0.13	0.11	0.13	0.12	0.92	0.6	
T-N	23	14	13.7	14	13.0	12.6	13.1	13.2	42.6			
2	1.1~1.2	1.73Q	NH4-N	23.2	14.9	22.1	17.4	17.0	14.0	13.7	11.4	41.3
			NO2-N	0.19	0.08	0.15	0.26	0.37	0.65	1.38	1.4	
			NO3-N	0.15	1.41	0.21	0.24	0.38	3.1	6.1	6.4	
			ORG-N	6.9	6.1	0.21	0.28	0.97	0.81	0.72	0.12	
			T-N	31.2	22.5	22.8	17.7	17.2	16.9	21.3	18.3	
3	1.9~2.0	1Q	NH4-N	15.9	14.3	13.5	13.2	8.6	6.2	4.4	4.8	31.2
			NO2-N	0.2	0.5	0.7	1.1	1.3	1.4	1.3	1.2	
			NO3-N	0.31	0.6	0.8	1.1	2.4	2.8	3.7	3.9	
			ORG-N	10.9	3.9	3.2	2.8	6.9	8.8	9.6	8.6	
			T-N	26.9	18.6	17.7	17.5	18.9	18.5	18.7	18.5	
4	1.9	2.45Q	NH4-N	28.9	15.4	17.3	15.5	7.8	9.2	16.1	10.6	56.6
			NO2-N	0.9	0.6	0.4	0.6	0.4	0.2	0.2	0.2	
			NO3-N	2.3	2.6	1.2	0.8	2.0	2.4	2.5	3.1	
			ORG-N	5.6	9.4	0.2	0.4	7.9	6.9	0.3	5.9	
			T-N	46.8	36.7	19.5	17.3	17.8	18.0	19.6	20.3	
5	1.6~1.8	2.45Q	NH4-N	18.3	9.8	13.4	12.6	8.2	6.9	6.9	4.8	55.1
			NO2-N	0.9	0.4	0.8	0.5	0.4	0.3	0.3	0.4	
			NO3-N	2.0	6.0	5.2	5.9	4.8	7.4	7.4	7.6	
			ORG-N	6.9	1.9	1.5	1.9	2.1	1.5	1.5	0.6	
			T-N	27.4	17.3	19.7	18.9	15.2	14.7	13.4	12.3	

Q = Daily flow (147 m³/Day).

ST = Sampling Point

Sampling time 2:00 PM Daily

School Plant: Nitrogen Removal

	Range	Average
Inflow ↓		
Anoxic Chamber 1 ↓		
Anoxic Chamber 2 ↓		
Anoxic Chamber 3 ↓		
Contact Aeration 1 ↓		
Contact Aeration 2 ↓		
Sedimentation ↓		
Disinfection ↓		
Outflow		
	Daily Flow (m ³ /day) Hourly Peak Flow (m ³) Peak Coefficient (-)	10.6~35.5 1.91~4.66 2.8~6.8
	Inflow	
	PH (-)	6.6~8.8
	SS (mg/l)	35.9~210
	BOD (mg/l)	130~393
	D-BOD (mg/l)	53~190
	COD (mg/l)	71.1~198
	TOC (mg/l)	67.4~162
	T-N (mg/l)	21.6~68.5
	T-P (mg/l)	1.93~558
	M-ALKALL (mg/l)	93.1~220
		- 135 227 127 126 118 45.8 3.92 151

22 Samples taken

Peak Coefficient - (hr. Peak Flow / Daily Flow) x 24

School Plant: Nitrogen Removal (cont'd)

		Volume (m ³)	Filter Media %
Anaerobic Tank	No.1	17.9	75%
	No.2	11.4	91%
	No.3	14.6	93%
Contact Aeration Tank	No.1	12.3	64%
	No.2	8.7	64%
Sedimentation Tank		7.0	

CHAMBER RETENTION TIME: (HRS.)

Test Condition	Before Return		After Return			
	Range	Av.	Range Av.	R<100% Av.	R=200% Range	
Anaerobic Tank						
Total	28.4~60.4	39.0	33.6~45.4	40.7	15.4~20.8	
Tank 1	11.6~24.6	16.3	17.0			
Tank 2	7.4~15.7	10.4	13.7~18.5	16.6	6.3~8.5	7.0
Tank 3	9.4-20.1	13.3	8.7~11.8	10.6	4.0~5.4	4.4
			11.2~15.1	13.6	5.1~6.9	5.7
Contact Aeration Tank						
Total	13.6~28.9	10.1	16.1~71.7	19.5	7.4~9.9	8.1
Tank 1	8.0~16.9	11.2	9.4~12.7	11.4	4.3~5.8	4.8
Tank 2	5.6~12.0	7.9	6.7~9.0	8.1	3.1~4.1	3.4
Sedimentation Tank	4.5~9.6	6.4	8.4~10.2	9.4	5.9~15.8	
			9.4			

Table 3

R=Return rate of treatment Liquid.

Return:

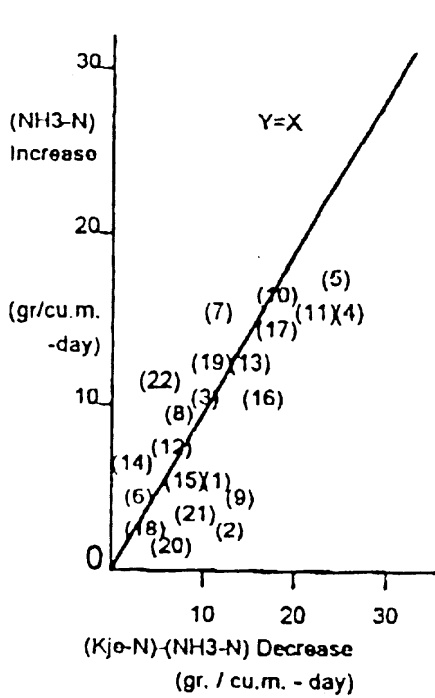
sedimentation tank ⇨ Anaerobic filter chamber

Contact aeration tank 2 ⇨ Anaerobic filter chamber 1

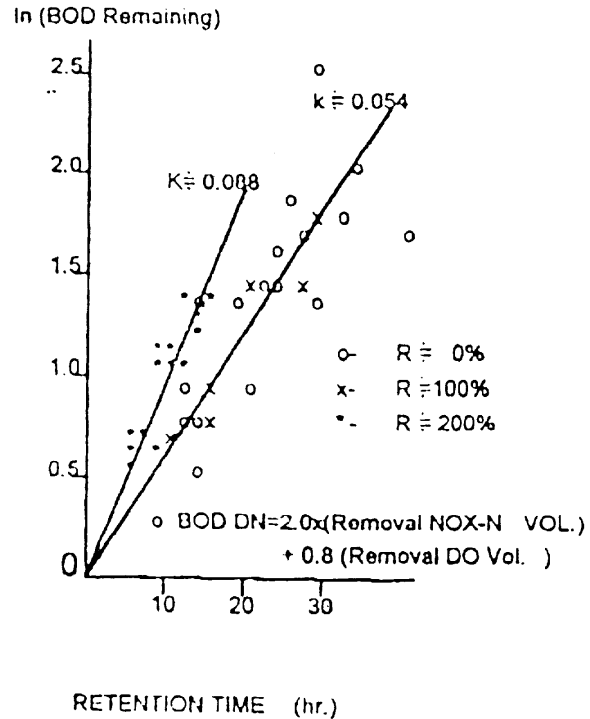
Conclusion

Table 3 illustrates that before influent return, the nitrogen removal effect in the anoxic tank is not stable, and the total BOD capacity load is 0.06 kg/m³ in the contact aeration tank and 0.12 kg/m³ in the contact aeration tank No. 1. The average rate of outward nitrification was 23.6% in the first tank, the total rate was 59%, and nitrogen removal was 32.6%.

In the 200% return rate condition, the nitrogen removal effect in the system is stable, and the BOD capacity load in the contact aeration tank has a similar rate before and after returning. The average rate of outward nitrification after returning was 35% in the first tank, and the total rate was as 84.5%. The average rate of nitrogen was 13.1mg/L and nitrogen removal was 72%.



Inc. and dec. of Organic Nitrogen in anoxic zone using filter media



IN (BOD Remaining) RELATIONSHIP

(X)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
day	84/5	84/7	84/9	84/11	85/1	85/3	85/5	85/7	85/9	85/11	86/1	86/3	86/5	86/7	86/9	86/11	87/1	87/3	87/5	87/7	87/10	87/11

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